

WHAT IS CLAIMED IS:

1. A damping system for an evacuated energy storage device, said device having a rotor assembly that is rotatably supported and guided by a bearing assembly, comprising a rolling element substantially confined between an inner and an outer race, and a stator assembly, the system comprising:

one or more flexible dampers, each having a first stiffness; and

a plurality of more rigid bumpers, each of said plurality having a second stiffness.

2. The damping system as recited in claim 1, wherein the one or more flexible dampers comprises a mesh damper.

3. The damping system as recited in claim 1, wherein the one or more flexible dampers comprises an elastomeric damper.

4. The damping system as recited in claim 3, wherein the elastomeric damper is made of silicon rubber.

5. The damping system as recited in claim 1, wherein said rotor assembly and said stator assembly are configured and arranged so as to be separated by a first clearance at substantially all locations except in proximity of the outer race of the bearing assembly, whereat said outer race of said bearing assembly is configured and arranged to be separated from one of said plurality of rigid

bumpers by a second clearance, to allow relative displacement of said stator assembly with respect to said rotor assembly.

6. The damping system as recited in claim 5, wherein the first clearance is about 13 to 17 mils.

7. The damping system as recited in claim 6, wherein the first clearance is about 15 mils.

8. The damping system as recited in claim 5, wherein the second clearance is about 8 to 12 mils.

9. The damping system as recited in claim 8, wherein the second clearance is about 10 mils.

10. The damping system as recited in claim 1, wherein said plurality of more rigid bumpers is fabricated from at least one of aluminum, metal, alloys, carbon, carbon-carbon composites, and carbon fiber composite materials.

11. The damping system as recited in claim 1, wherein said plurality of more rigid bumpers is configured and arranged so as to substantially limit further relative displacement between the rotor assembly and stator assembly by frictionally engaging the outer race of the bearing assembly after an initial, first relative displacement equal in magnitude to a second clearance that separates

said outer race of said bearing assembly from said plurality of more rigid bumpers.

12. The damping system as recited in claim 11, wherein said second clearance has a magnitude of about 8 to 12 mils.

13. The damping system as recited in claim 12, wherein said second clearance has a magnitude of about 10 mils.

14. The damping system as recited in claim 1, wherein the first stiffness of the one or more flexible dampers is about 500 lb/in to about 4000 lb/in.

15. The damping system as recited in claim 14, wherein the first stiffness of the one or more flexible dampers is about 1200 lb/in.

16. The damping system as recited in claim 1, wherein the second stiffness of the plurality of more rigid bumpers is about 50,000 lb/in to about 250,000 lb/in.

17. The damping system as recited in claim 16, wherein the second stiffness of the plurality of more rigid bumpers is about 200,000 lb/in.

18. A self-contained bearing assembly system for an evacuated energy storage device, said device further having a rotor assembly and a stator assembly, which assemblies are separated by a first clearance and a second clearance, the system comprising:

a bearing assembly for rotatably supporting and guiding said rotor assembly, the bearing assembly further comprising:

an inner race,

an outer race, and

a rolling element that is rollably disposed and confined between said inner and outer races;

a mounting assembly, the mounting assembly further comprising:

an upper damper grounding plate,

a lower damper grounding plate, and

a circumferential mounting plate;

one or more flexible dampers, wherein an inner periphery of said one or more flexible dampers is in tight interference fit with said outer race of said bearing assembly and an outer periphery of said one or more flexible dampers is securely and removably attached to said circumferential mounting plate; and

a plurality of more rigid bumpers, wherein at least one of said plurality of more rigid bumpers is configured and arranged on said upper damper grounding plate so as to be disposed in proximity of said outer race of said bearing assembly and one or more of said plurality of more rigid bumpers is configured and arranged on said lower damper grounding plate so as to be disposed in proximity of said outer race of said bearing assembly.

19. The bearing assembly system as recited in claim 18, wherein the one or more flexible damper comprises a mesh damper.

20. The bearing assembly system as recited in claim 18, wherein the one or more flexible damper comprises an elastomeric damper.

21. The bearing assembly system as recited in claim 20, wherein the elastomeric damper is made of silicon rubber.

22. The bearing assembly system as recited in claim 18, wherein the plurality of more rigid bumpers are configured and arranged so as to be separated from the outer race of the bearing assembly by a second clearance and elsewhere, the rotor assembly and the stator assembly are configured and arranged so as to be separated by a first clearance to allow relative displacement between said rotor and stator assemblies.

23. The bearing assembly system as recited in claim 22, wherein the first clearance is about 13 to 17 mils.

24. The bearing assembly system as recited in claim 23, wherein the first clearance is about 15 mils.

25. The bearing assembly system as recited in claim 22, wherein the second clearance is about 8 to 12 mils.

26. The bearing assembly system as recited in claim 25, wherein the second clearance is about 10 mils.

27. The bearing assembly system as recited in claim 18, wherein said upper and lower grounding plates and said plurality of more rigid bumpers are fabricated from at least one of aluminum, metal, alloys, carbon, carbon-carbon composites and carbon fiber composite materials.

28. The bearing assembly system as recited in claim 18, wherein said plurality of more rigid bumpers is configured and arranged so as to substantially limit further relative displacement between the rotor and stator assemblies by frictionally engaging the outer race of the bearing assembly after an initial relative displacement equal in magnitude to a second clearance that separates said outer race of said bearing assembly from said plurality of more rigid bumpers.

29. The bearing assembly system as recited in claim 28, wherein said second clearance has a magnitude of about 8 to 12 mils.

30. The bearing assembly system as recited in claim 29, wherein said second clearance has a magnitude of about 10 mils.

31. The bearing assembly system as recited in claim 18, wherein the first stiffness of the one or more flexible dampers is about 500 lb/in to about 4000 lb/in.

32. The bearing assembly system as recited in claim 31, wherein the first stiffness of the one or more flexible dampers is about 1200 lb/in.

33. The bearing assembly system as recited in claim 18, wherein the second stiffness of the plurality of more rigid bumpers is about 50,000 lb/in to about 250,000 lb/in.

34. The bearing assembly system as recited in claim 33, wherein the second stiffness of the plurality of more rigid bumpers is about 200,000 lb/in.

35. The bearing assembly system as recited in claim 18, wherein the system further comprises a gasket that is fixedly attached to the plurality of more rigid bumpers, wherein said gasket is less rigid than said plurality of more rigid bumpers.

36. A method of damping an evacuated energy storage system that is subject to extreme external vibrations, said system having a stator assembly, a rotor assembly, and a bearing assembly that rotatably supports and guides said rotor assembly, the method comprising the steps of:

controlling a first relative displacement of the stator assembly with respect to the rotor assembly; and

arresting further relative displacement of said stator assembly with respect to said rotor assembly.

37. The method as recited in claim 36, wherein said first relative displacement of the stator assembly with respect to the rotor assembly is controlled by providing one or more flexible bearing dampers.

38. The method as recited in claim 36, wherein subsequent to the first relative displacement further relative displacement of said stator assembly with respect to said rotor assembly is limited substantially by providing a plurality of more rigid bumpers that frictionally engage the bearing assembly.

39. An evacuated energy storage device, said device comprising:  
a bearing assembly; said bearing assembly further comprising:  
    an inner race,  
    an outer race, and  
    a rolling element, wherein said rolling element is substantially confined between said inner and said outer race;  
a rotor assembly that is rotatably supported and guided by said bearing assembly;  
a stator assembly; and  
a dual stiffness damping system, the system comprising:  
    one or more flexible dampers, each having a first stiffness; and  
    a plurality of more rigid bumpers, each of said plurality having a second stiffness.

40. The evacuated energy storage device as recited in claim 39, wherein the one or more flexible dampers of the dual stiffness damping system comprise a mesh damper.

41. The evacuated energy storage device as recited in claim 39, wherein the one or more flexible dampers of the dual stiffness damping system comprise an elastomeric damper.

42. The evacuated energy storage device as recited in claim 41, wherein the elastomeric damper is made of silicon rubber.

43. The evacuated energy storage device as recited in claim 39, wherein said rotor assembly and said stator assembly are configured and arranged so as to be separated by a first clearance at substantially all locations except in proximity of the outer race of the bearing assembly, whereat said outer race of said bearing assembly is configured and arranged so as to be separated from one of said plurality of rigid bumpers by a second clearance, to allow relative displacement of said stator assembly with respect to said rotor assembly.

44. The evacuated energy storage device as recited in claim 43, wherein the first clearance is about 13 to 17 mils.

45. The evacuated energy storage device as recited in claim 44, wherein the second clearance is about 8 to 12 mils.

46. The evacuated energy storage device as recited in claim 39, wherein said plurality of more rigid bumpers is fabricated from at least one of aluminum, metal, alloys, carbon, carbon-carbon composites, and carbon fiber composite materials.

47. The evacuated energy storage device as recited in claim 39, wherein the first stiffness of the one or more flexible dampers is about 500 lb/in to about 4000 lb/in.

48. The evacuated energy storage device as recited in claim 39, wherein the second stiffness of the plurality of more rigid bumpers is about 50,000 lb/ in to about 250,000 lb/in.

49. An evacuated energy storage device, said device comprising:  
a self-contained bearing assembly system, said system comprising:  
a bearing assembly for rotatably supporting and guiding said rotor assembly, the bearing assembly further comprising:  
an inner race,  
an outer race, and  
a rolling element that is rollably disposed and confined between said inner and outer races;  
a mounting assembly, the mounting assembly further comprising:  
an upper damper grounding plate,  
a lower damper grounding plate, and  
a circumferential mounting plate;

one or more flexible dampers, wherein an inner periphery of said one or more flexible dampers is in tight interference fit with said outer race of said bearing assembly and an outer periphery of said one or more flexible dampers is securely and removably attached to said circumferential mounting plate; and

a plurality of more rigid bumpers, wherein at least one of said plurality of more rigid bumpers is configured and arranged on said upper damper grounding plate so as to be disposed in proximity of said outer race of said bearing assembly and one or more of said plurality of more rigid bumpers is configured and arranged on said lower damper grounding plate so as to be disposed in proximity of said outer race of said bearing assembly;

a rotor assembly that is rotatably supported and guided by said bearing assembly; and

a stator assembly.

50. The evacuated energy storage device as recited in claim 49, wherein the one or more flexible damper comprises a mesh damper.

51. The evacuated energy storage device as recited in claim 49, wherein the one or more flexible damper comprises an elastomeric damper.

52. The evacuated energy storage device as recited in claim 51, wherein the elastomeric damper is made of silicon rubber.

53. The evacuated energy storage device as recited in claim 49, wherein the plurality of more rigid bumpers are configured and arranged so as to be separated from the outer race of the bearing assembly by a second clearance and elsewhere, the rotor assembly and the stator assembly are configured and arranged so as to be separated by a first clearance to allow relative displacement between said rotor and stator assemblies.

54. The evacuated energy storage device as recited in claim 53, wherein the first clearance is about 13 to 17 mils.

55. The evacuated energy storage device as recited in claim 54, wherein the first clearance is about 15 mils.

56. The evacuated energy storage device as recited in claim 53, wherein the second clearance is about 8 to 12 mils.

57. The evacuated energy storage device as recited in claim 56, wherein the second clearance is about 10 mils.

58. The evacuated energy storage device as recited in claim 49, wherein said upper and lower grounding plates and said plurality of more rigid bumpers are fabricated from at least one of aluminum, metal, alloys, carbon, carbon-carbon composites, and carbon fiber composite materials.

59. The evacuated energy storage device as recited in claim 49, wherein said plurality of more rigid bumpers is configured and arranged so as to substantially limit further relative displacement between the rotor and stator assemblies by frictionally engaging the outer race of the bearing assembly after an initial relative displacement equal in magnitude to a second clearance that separates said outer race of said bearing assembly from said plurality of more rigid bumpers.

60. The evacuated energy storage device as recited in claim 59, wherein said second clearance has a magnitude of about 8 to 12 mils.

61. The evacuated energy storage device as recited in claim 60, wherein said second clearance has a magnitude of about 10 mils.

62. The evacuated energy storage device as recited in claim 49, wherein the first stiffness of the one or more flexible dampers is about 500 lb/in to about 4000 lb/in.

63. The evacuated energy storage device as recited in claim 49, wherein the second stiffness of the plurality of more rigid bumpers is about 50,000 lb/in to about 250,000 lb/in.

64. The evacuated energy storage device as recited in claim 49, wherein the self-contained bearing assembly system further comprises a gasket that is fixedly attached to the plurality of more rigid bumpers, wherein said gasket is less rigid than said plurality of more rigid bumpers.